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(54) Abstract Title
Arrangement platform for connecting optical fibers to optical waveguide

(57) An optical fiber and waveguide connection structure including optical fibers 200, an optical waveguide device 210 whose plane including a waveguide core stands out over the surface of a substrate 212 and an arrangement platform 220 which is placed so that the center of each of the optical fibers can face the center of the waveguide core of the optical waveguide device, and has depressed grooves 222 for the optical fibers and a depressed groove 221 for the prominent portion of the optical waveguide device.

The arrangement platform (320, Fig 3) may have a plate (321, Fig 3) for supporting the optic fibres. The grooves (423, Fig 4) for the optic fibres may be V-shaped.

FIG. 2

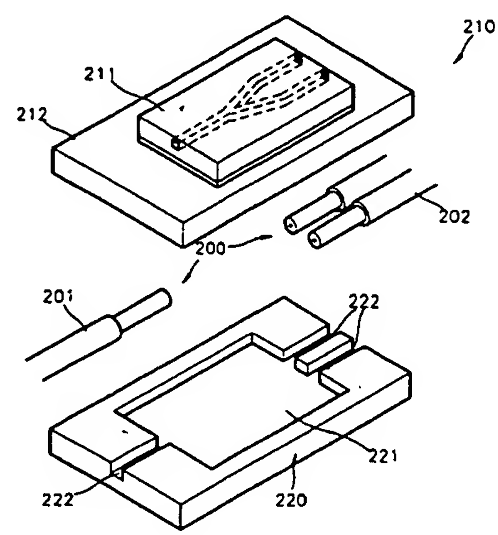

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FIG. 1 (PRIOR ART)

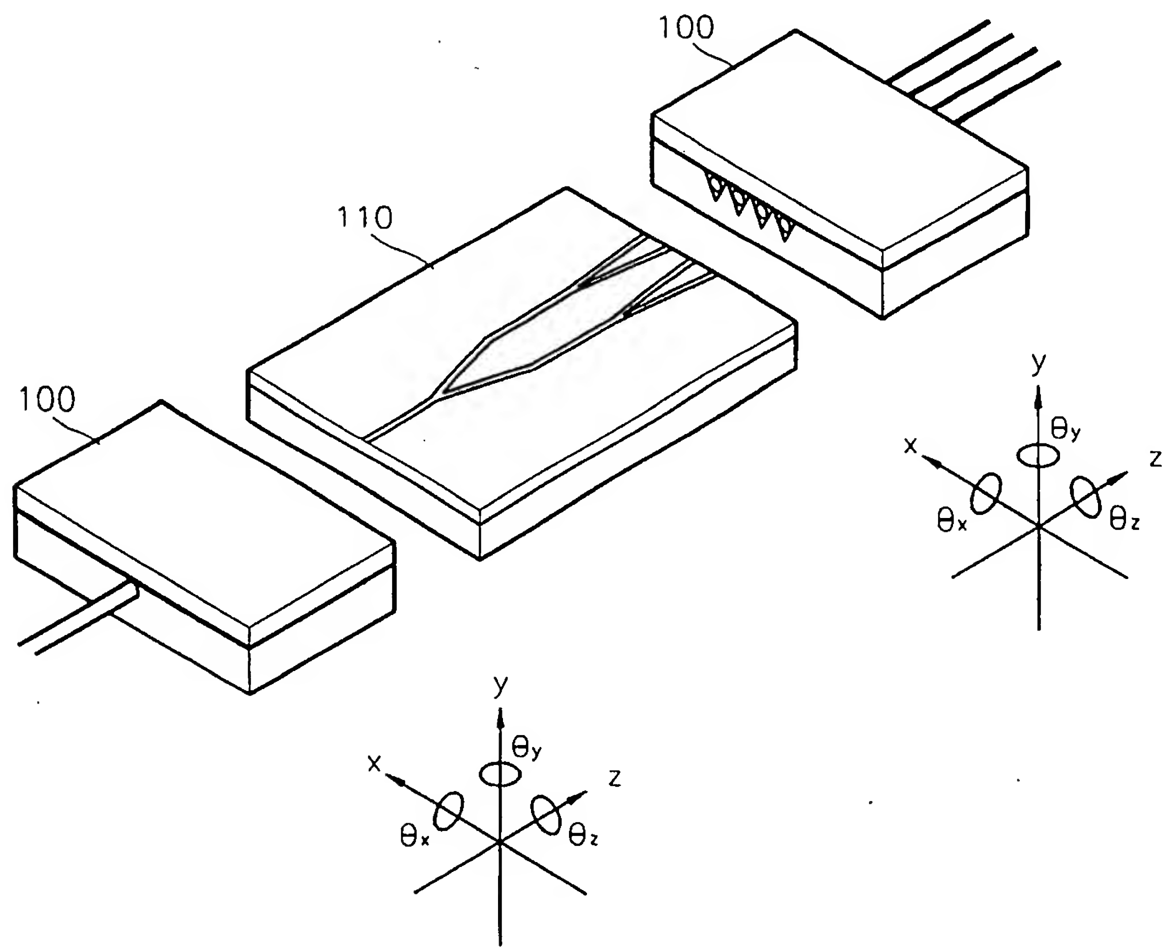


FIG. 2

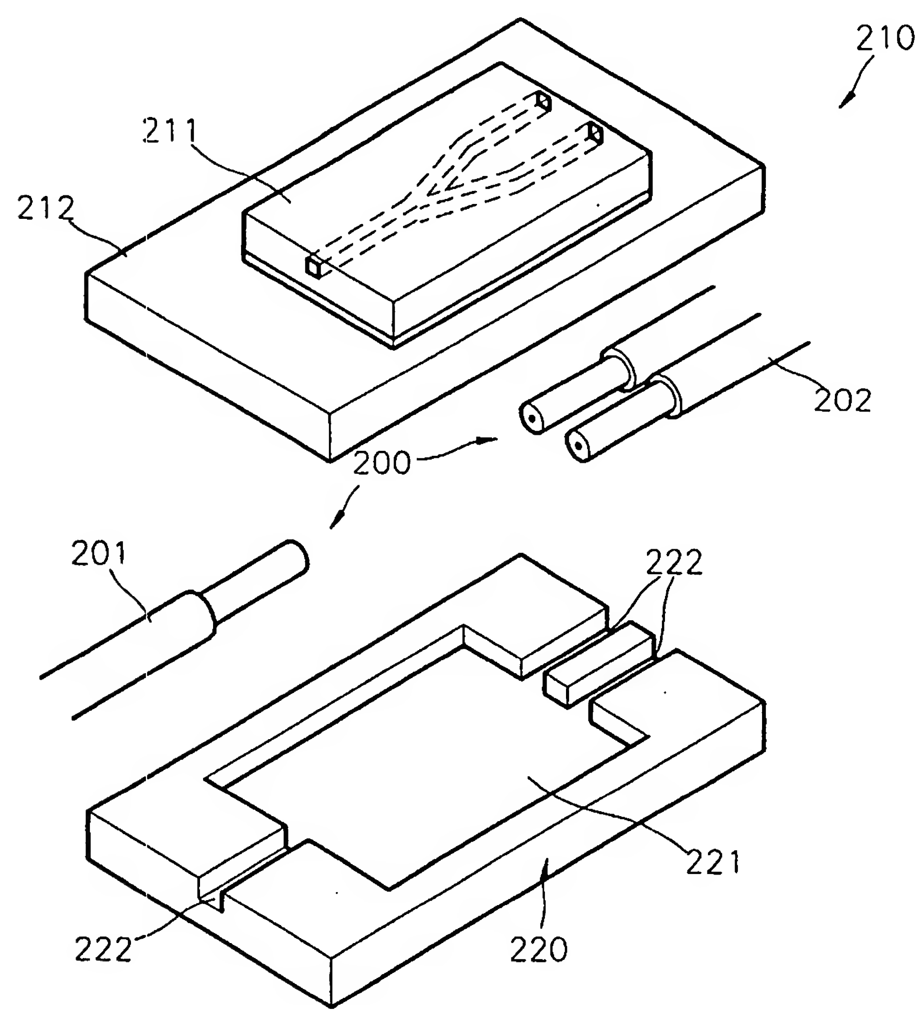


FIG. 3

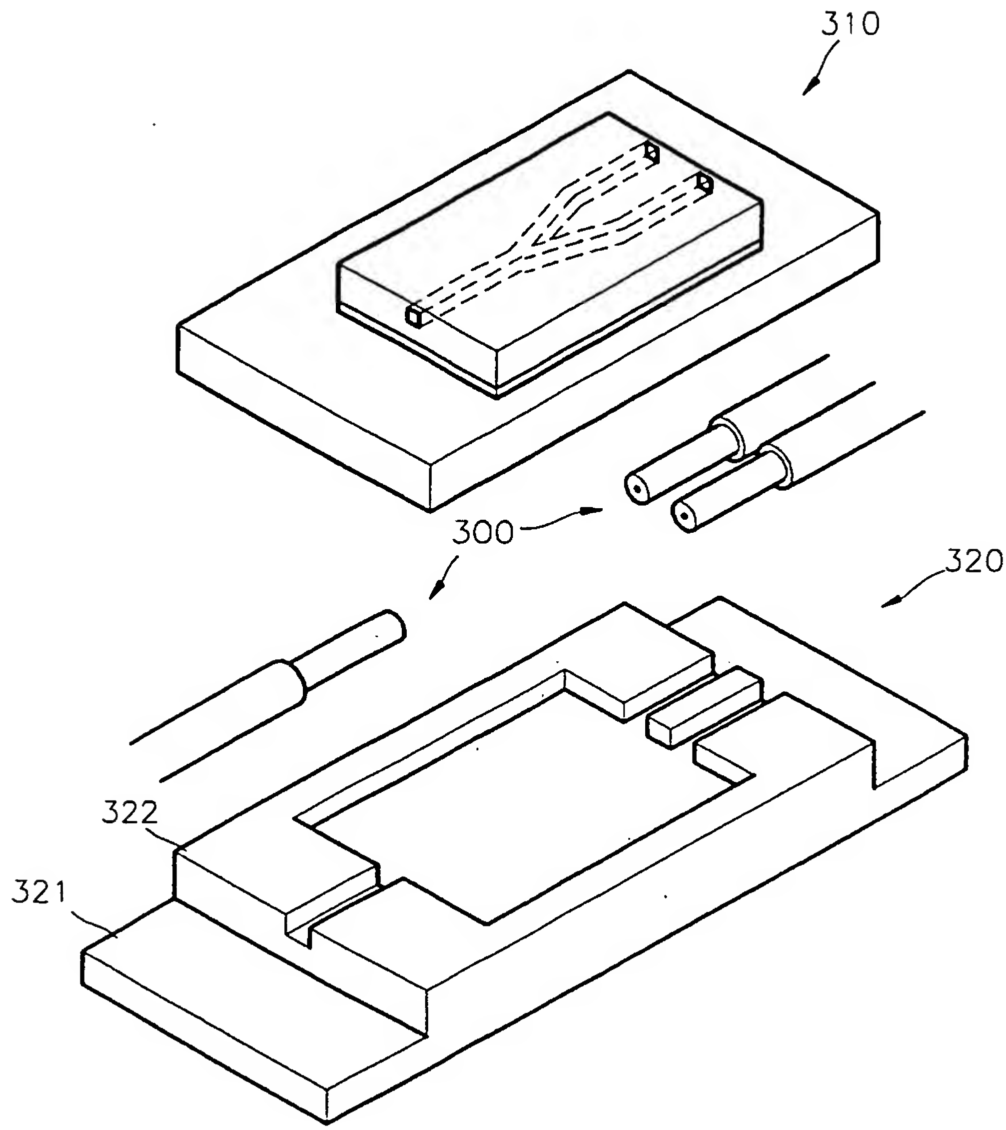
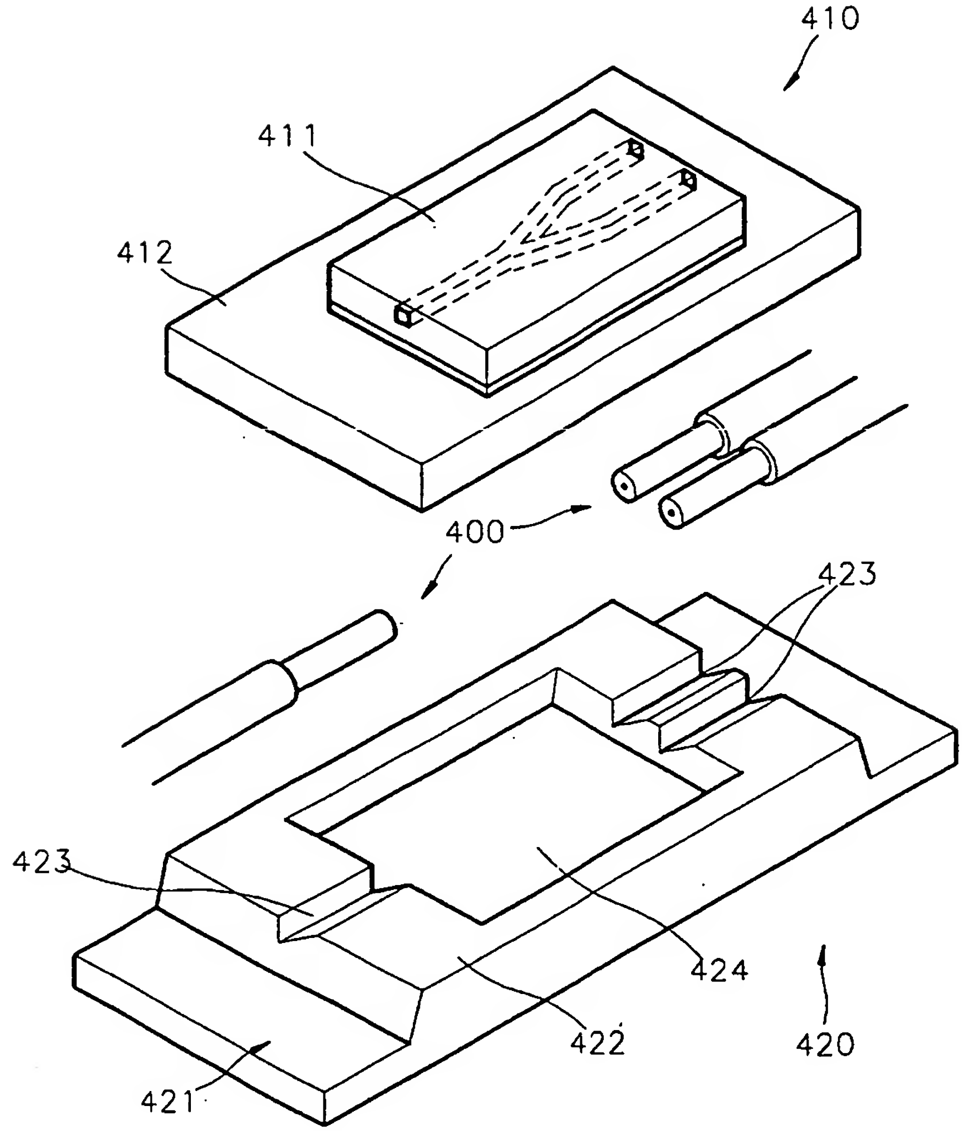


FIG. 4



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STRUCTURE FOR CONNECTING OPTICAL FIBERS TO OPTICAL WAVEGUIDE

The present invention relates to a structure in which an optical fiber and an optical waveguide are connected to each other, and more particularly, to an optical fiber and optical waveguide connection structure in which optical fibers and an optical waveguide are passively connected to each other on an arrangement platform.

In general, an optical fiber array block module comprised of an array of optical fibers, as many as the number of input/output waveguides of an optical waveguide device, is fabricated to combine the optical waveguide device with the optical fibers. The optical fiber array block module is formed by mounting an optical fiber on a block having V-shaped grooves of uniform intervals, coating an adhesive on the optical fiber, fixing the optical fiber with a coverlet, and polishing the cross-section of the block. The input/output cross-section of the optical waveguide device undergoes a polishing process to reduce a junction loss occurring when coupled to the optical fiber array block module. After light is waveguided to an input optical fiber of the optical fiber array block module, the optical waveguides are accurately arranged such that a maximum output beam can be emitted from the output end of the waveguide. While the maximum output beam is emitted from the waveguide output end, the optical fiber array block module and the optical waveguide device are fixed and finally coupled.

FIG. 1 shows a conventional optical waveguide device and a conventional optical fiber array block module. Here, the arrangement of optical waveguide devices 100 and an optical fiber array block module 110 is shown in a state just before being combined with one another. Three-dimensional coordinates on the lower part of FIG. 1 are illustrated to show the direction of a beam to be irradiated via the input end of the optical fiber array block module 110 and the arrangement direction of each module. When the beam irradiated via the input end slips out of

the output end of the optical fiber array block module 110 via the optical waveguide device 100, an arra· :ment position with a minimum loss is found, to thus complete the combination

As described above, whe the optical fiber array block module 110 and the optical waveguide device 100 are combined in an active arrangement manner, an optical source for emitting light is required, and a device such as an optical detector for loss calculation must be included. Also, it takes much time and effort to adjust the direction of arrangement.

According to a first aspect of the invention there is provided an optical fiber and waveguide connection structure comprising: optical fibers; an optical waveguide device whose plane including a waveguide core stands out over the surface of a substrate; and an arrangement platform which is placed so that the center of each of the optical fibers can face the center of the waveguide core of the optical waveguide device, and has depressed grooves for the optical fibers and a depressed groove for the prominent portion of the optical waveguide device.

It is therefore an advantage of the present invention to provide an optical fiber and optical waveguide connection structure in which an optical waveguide device and an optical fiber array block are combined in a passive arrangement manner so that they can be rapidly connected to each other without a separate optical source.

Preferably, when the optical waveguide device is mounted on the arrangement platform, a non-prominent substrate portion serves as a coverlet of the optical fibers to be mounted on the arrangement platform.

It is preferable that the arrangement platform further comprises a supporter for supporting an optical fiber portion extending from the depressed grooves when the optical fibers are mounted on the depressed grooves.

It is preferable that on the arrangement platform, the height from the surface of the groove etched to a depth where the prominent portion of the waveguide device can fit to the center of the waveguide core when the waveguide device is put into the depressed groove is the same as the radius of the cross-section of each of the optical fibers.

It is preferable that in the optical waveguide device, the height from the substrate to the center of the optical waveguide device is the same as the radius of the optical fiber cross-section.

According to a second aspect of the invention there is provided an optical fiber and waveguide connection structure comprising: optical fibers; an optical waveguide device whose plane including a waveguide stands out over the surface of a substrate; and an arrangement platform which is placed so that the center of each of the optical fibers can face the center of the waveguide core of the optical waveguide device, has V-shaped grooves for the optical fibers and a depressed groove for the prominent plane of the optical waveguide device, and includes a supporter for supporting an extending portion of each of the optical fibers when the optical fibers are mounted on the V-shaped grooves.

There now follows a description of preferred embodiments of the invention, by way of non-limiting example, with reference being made to the attached drawings in which:

FIG. 1 is a perspective view of a conventional optical waveguide device and a conventional optical fiber array block module;

FIG. 2 is a perspective view of an optical fiber and optical waveguide connection structure according to an embodiment of the present invention;

FIG. 3 is a perspective view of an optical fiber and optical waveguide connection structure according to another embodiment of the present invention; and

FIG. 4 is a perspective view of an optical fiber and optical waveguide connection structure according to still another embodiment of the present invention.

Referring to FIG 2, an optical fiber and optical waveguide connection structure includes optical fibers 200, an optical waveguide device 210, and an arrangement platform 220. FIG. 2 shows an optical fiber 201 to be connected to the input portion of the optical waveguide device 210 and optical fibers 202

installed at a portion to which a signal passed through the optical waveguide device 210 is output. The number of optical fibers 202 at the output portion depends on the number of branches of the optical waveguide device 210. The optical waveguide device 210 is etched until a prominent portion 211 including the core of an optical waveguide stands out over the surface of a substrate 212. The arrangement platform 220, on which the optical fibers 200 and the optical waveguide device 210 are arranged and connected, has depressed grooves 222 for arranging the optical fibers 200 and a depressed groove 221 for housing the prominent portion 211 of the optical waveguide device 210, formed on a substrate having a predetermined thickness. The depth of the depressed grooves for arranging the optical fibers 200 must be equal to or a little smaller than the diameter of the cross-section of the optical fibers. The depth of the depressed groove 221 into which the prominent portion 211 of the optical waveguide device 210 is to be put is the same as those of the depressed grooves for the optical fibers 200. When the optical fibers 200 and the optical waveguide device 210 are arranged and connected to each other on the arrangement platform 220, the center of each optical fiber, i.e., the center of the core of each optical fiber must accurately contact the center of the optical waveguide device 210, i.e., the center of the optical waveguide core. Such a connection must be properly calculated in advance upon etching the depression of the arrangement platform, to thus accomplish accurate etching. The substrate 212 of the optical waveguide device 210 serves as a coverlet for fixing the optical fibers 200 to the optical waveguide device 210 on the arrangement platform 220.

When the optical fibers 200 and the optical waveguide device 210 are mounted and connected to each other on the arrangement platform, the optical fibers 200 is fixed by the substrate 212 of the optical waveguide device 210, i.e., a substrate portion 212 which is not etched from the optical waveguide device 210. The prominent portion 211 of the optical waveguide device 210 is inserted into the depression 221 of the arrangement platform 220. Here, the height from the substrate 212 of the optical waveguide device 210 to the center of the waveguide core must be equal to the radius of the cross-section of the optical fibers 200.

FIG. 3 shows an optical fiber and optical waveguide device connection structure according to another embodiment of the present invention, comprising

optical fibers 300, an optical waveguide device 310, and an arrangement platform 320. The optical fibers 300 and the optical waveguide device 310 are the same as described in FIG. 2. In the arrangement platform 320, an arrangement part 322 for connecting the optical fibers 300 to the optical waveguide device 310 exists on a plate 321 for supporting the optical fibers, in contrast to FIG. 2. The depth of the depression of the arrangement part 322 is the same as described in FIG. 2.

FIG. 4 shows an optical fiber and optical waveguide device connection structure according to still another embodiment of the present invention, comprising optical fibers 400, an optical waveguide device 410, and an arrangement platform 420. The optical fiber 400 and the optical waveguide device 410 are the same as described in FIG. 2. The arrangement platform 420 is comprised of a plate 421 for supporting the optical fibers 400 and an arrangement part 422. The arrangement part 422 has a V-etched groove (V groove) for mounting the optical fibers 400 and a depression into which the prominent portion of the optical waveguide device 410 is to be fit. The etching depths of the V grooves 423 and the depressed groove 424 for the optical waveguide must be smaller than or equal to the diameter of the cross-section of each of the optical fibers 400. The height of the prominence 411 of the optical waveguide device 410 must be controlled so that the height from the surface of a substrate 412 to the center of the waveguide core can be the same as the radius of the cross-section of the optical fibers 400. The total height of the prominence 411 of the optical waveguide device 410 must be a little smaller than the diameter of the cross-section of the optical fibers 400.

The characteristics and fabrication method of components for realizing FIGS. 2 through 4 will now be described. A connection of the optical fibers to the optical waveguide device depending on the combination of the components will be described as follows. First, the arrangement platform 220, as a basic block in which the optical fibers 200 and the optical waveguide device 210 are arranged, is characterized in that it has a groove 221 for mounting the optical waveguide device and grooves 222 for mounting optical fibers at an input and output portion at predetermined intervals. Anisotropic etching of a silicon substrate can be used to fabricate the arrangement platform 220. The arrangement platform 220 of FIG. 2 is manufactured by forming an etch mask pattern of Si_3N_4, or other material on a

silicon wafer excluding portions on which a waveguide device chip and an optical fiber are to be mounted, and etching the pattern using an etch solution of KOH or other solution. The arrangement platform 420 of FIG. 4 is the case of manufacturing the silicon wafer using the anisotropic etch method. The optical waveguide devices 210, 310 and 410 of FIGS. 2 through 4 have the edge removed to a predetermined depth so as to be accurately seated, respectively, on the arrangement platforms 220, 320 and 420. Such an optical waveguide device is realized by etching the edge of the optical waveguide device using a dry-etch method such as reactive ion etching (RIE) or by cutting the edge to a predetermined depth using an accurate grinder. Here, the cross-section of an input and output optical waveguide, i.e., the cross-section of an optical waveguide to be connected to optical fibers at an input and output portion, must be accurately processed to minimize optical loss upon connecting the optical fiber to the optical waveguide. Here, the optical fiber also has an accurately-cut cross-section to minimize optical loss when coupled to the cross-section of the input and output optical waveguide.

The coupling between the components of FIGS. 2 through 4 will now be described. In FIGS. 2 through 4, when the optical fiber, the optical waveguide device, and the arrangement platform are coupled to one another, the optical fibers are inserted into the grooves for mounting the optical fibers on the arrangement platform, and the optical waveguide device is put into the groove for the optical waveguide device on the arrangement platform, thereby completing the coupling. Here, the cross-sections of the optical fibers and optical waveguide meet and correspond to each other, and particularly, the optical fibers and the optical waveguide core meet so as to have the same center. When the optical fibers are mounted on the grooves of the arrangement platform, about 20 to 30μm of the optical fibers protrudes from the surface extending from the grooves for mounting the optical fibers on the arrangement platform. When the optical waveguide device is mounted on the arrangement platform, a removed portion (e.g., a portion of the substrate 212 of FIG. 2) of the edge of the optical waveguide device serves as a plate for fixing the optical fibers. The diameter of a typical optical fiber is 125μm, so the depth of the groove for mounting an optical fiber on the arrangement platform is about 95 to 105μm. In this way, the substrate

portion being the etched-out edge of the optical waveguide device is mounted on the optical fibers on the arrangement platform upon coupling. When the radius of each of the optical fibers is 62.5μm, the center of the waveguide device core must be 62.5μm high from the substrate surface of the optical waveguide device, i.e., from where the prominent portion begins to stand out, in order to match the center of the core of the optical waveguide device with the center of the optical fiber. Therefore, the optical fibers and the optical waveguide device are arranged upward and downward, i.e., in the direction where an optical signal travels, on the arrangement platform. The left-to-right length of the prominence-shaped plate of the optical waveguide device based on the input and output portion of the optical waveguide core must be equal to the left-to-right length of the depression groove of the arrangement platform, i.e., the length of a direction perpendicular to the direction in which an optical signal travels. Also, the optical waveguide device must be manufactured in advance so that the center of its input and output portion core can face the input and output portion of each of the optical fibers, thereby allowing arrangement of the optical fibers and optical waveguide device in right and left directions. As shown in FIGS. 3 and 4, the arrangement platform plate for supporting the optical fibers prevents damage to the optical fiber due to removal of an optical fiber coating layer, when the optical fibers are mounted on the grooves on the arrangement platform. The aforementioned connection structure between optical fibers and an waveguide device is achieved using a passive arrangement method instead of an active arrangement method of attaching optical fibers to an optical waveguide device, and thus does not require an optical source, an optical detector, an accurate arrangement device, etc., which are necessary for active arrangement connection.

According to the present invention, an optical source, an optical detector, etc. are not used to connect the optical fiber to the optical waveguide based on a passive arrangement structure, thus reducing the costs. Also, a rapid connection can be achieved.

CLAIMS

1. An optical fiber and waveguide connection structure comprising:

optical fibers;

an optical waveguide device whose plane including a waveguide core stands out over the surface of a substrate; and

an arrangement platform which is placed so that the center of each of the optical fibers can face the center of the waveguide core of the optical waveguide device, and has depressed grooves for the optical fibers and a depressed groove for the prominent portion of the optical waveguide device.

2. The optical fiber and waveguide connection structure as claimed in claim 1, wherein when the optical waveguide device is mounted on the arrangement platform, a non-prominent substrate portion serves as a coverlet of the optical fibers to be mounted on the arrangement platform.

3. The optical fiber and waveguide connection structure as claimed in claim 1 or 2, wherein the arrangement platform further comprises a supporter for supporting an optical fiber portion extending from the depressed grooves when the optical fibers are mounted on the depressed grooves.

4. The optical fiber and waveguide connection structure as claimed in any preceding claim, wherein on the arrangement platform, the height from the surface of the groove etched to a depth where the prominent portion of the waveguide device can fit to the center of the waveguide core when the waveguide device is put into the depressed groove is the same as the radius of the cross-section of each of the optical fibers.

5. The optical fiber and waveguide connection structure as claimed in any preceding claim, wherein in the optical waveguide device, the height from the substrate to the center of the optical waveguide device is the same as the radius of the optical fiber cross-section.

6. An optical fiber and waveguide connection structure comprising:

optical fibers;

an optical waveguide device whose plane including a waveguide stands out over the surface of a substrate; and

an arrangement platform which is placed so that the center of each of the optical fibers can face the center of the waveguide core of the optical waveguide device, has V-shaped grooves for the optical fibers and a depressed groove for the prominent plane of the optical waveguide device, and includes a supporter for supporting an extending portion of each of the optical fibers when the optical fibers are mounted on the V-shaped grooves.

7. A structure generally as herein described, with reference to or as illustrated in Figures 2 to 4 of the accompanying drawings.

Application No:	GB 9827896.3	**Examiner:**	Chris Ross
Claims searched:	1-7	**Date of search:**	3 March 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): G2J(JGDB)

Int Cl (Ed.6): G02B

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0798579 A1	(LUCENT) Figs 1-6	1 at least
"	EP 0532470 A1	(CSEM) Fig 2	"
"	EP 0504882 A2	(FUJITSU) Figs 2, 3	"
"	US 5574806 A	(BOSCH) Figs 2A, 2B, 3	"
"	US 5555331 A	(RADIALL) the Figs	1, 6 at least
"	JP 030039703 A	(SEI) Figs 1,5	1 at least
"	Electronics Letters 26 September 1996 Vol 32 No 20 pp 1916-7 Fig 1		"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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